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Forest insect and disease conditions

British Columbia & Yukon 1988

C.S. Wood and G.A. Van Sickle

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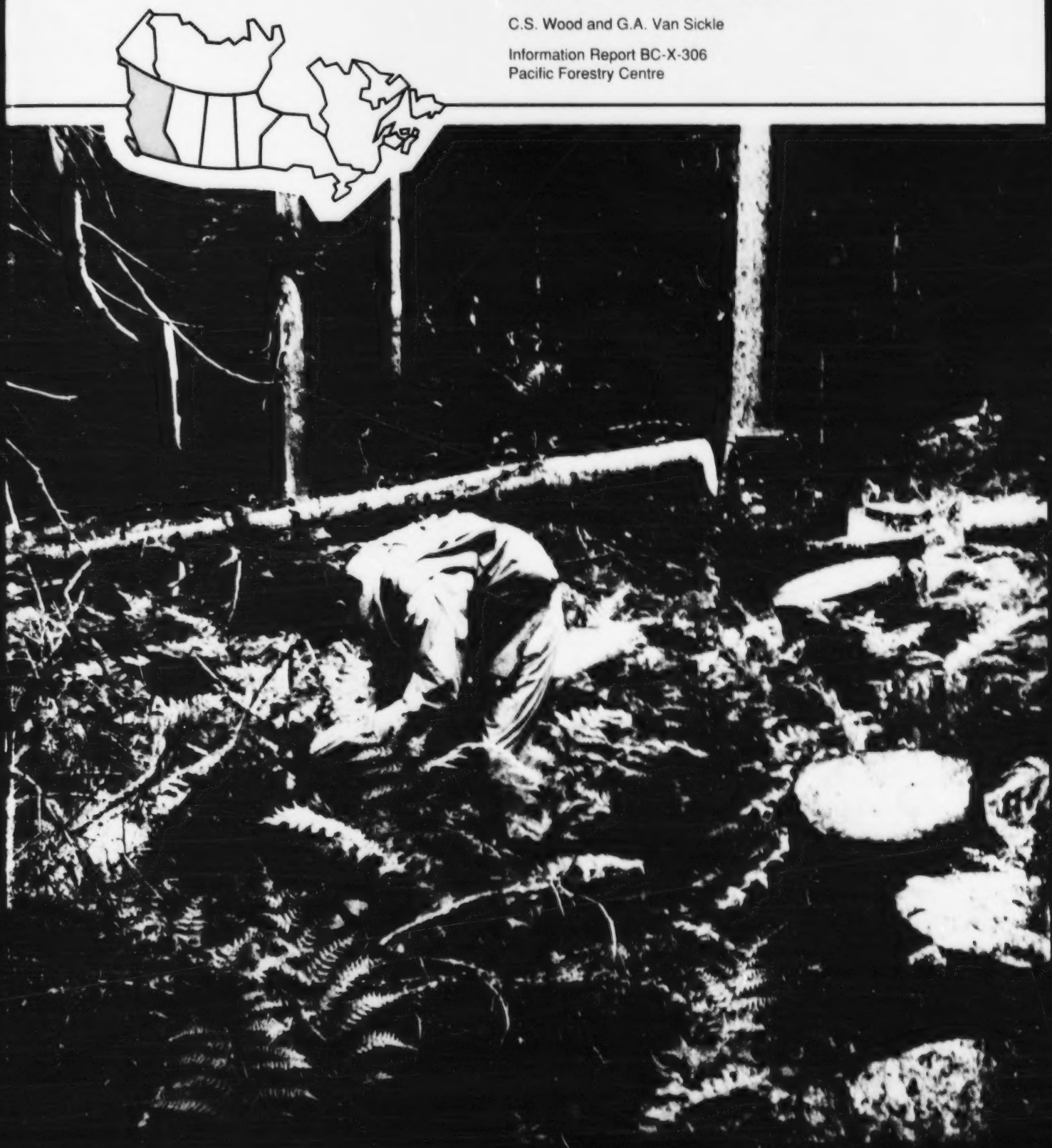
Pacific Forestry Centre



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Abstract

This summary of forest pest conditions in British Columbia and the Yukon Territory in 1988 highlights pests that are or may become major forest management problems. It was compiled from records and field reports of 11 Forest Insect and Disease Survey rangers with contributions from forest agencies, researchers, and industry. More than 40 forest pests are discussed and some predictions are made for 1989.

Résumé

Le présent résumé sur les ravageurs des forêts de la Colombie-Britannique et du Yukon, en 1988, porte sur ceux qui posent ou peuvent poser de graves problèmes aux aménagistes. Il synthétise les observations et les rapports de 11 techniciens du RIMA, en intégrant les contributions des chercheurs, des organismes et de l'industrie forestière. Plus de 40 ravageurs font l'objet de discussion et de prévisions pour 1989.

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Introduction

The Forest Insect and Disease Survey (FIDS) of Forestry Canada is responsible for producing an annual national overview of important forest pest conditions and their implications. In the Pacific region, general surveys are conducted to detect and monitor important forest insects, diseases, and environmental factors. Additionally, surveys and records are maintained in support of quarantine programs, forest research projects, and insect collections and herbaria. Surveys are conducted with the cooperation of the British Columbia Forest Service, other federal and provincial agencies, municipalities, the forest industry, educational centres, and research programs at the Pacific Forestry Centre and other Forestry Canada centres across Canada.

This regional report reviews the status and impact of major forest insects and diseases and the effects of environmental factors on conifer and broadleaf forests in British Columbia and the Yukon Territory in 1988, and forecasts trends of some pests and their potential damage in 1989. Damage trends and expansion of infestations can be determined by comparison to previous years' reports.

Throughout this report, the subjective terms "light," "moderate," and "severe" are used to describe the level of total defoliation. Unless otherwise stated, these are defined as 1 to 25%, 26 to 50%, and more than 50% defoliated, respectively.

The report is compiled from information obtained largely from field observations and records of 11 FIDS rangers collected during their field assignments from late May to October in six provincial forest regions and the Yukon Territory. More detailed information on the status of forest pests is available in reports compiled by the following FIDS rangers:

Cariboo - Bob Erickson and Bob Ferris
Kamloops - Peter Koot and Jim Loranger
Nelson - Leo Unger and John Vallentgoed
Prince George - Rod Turnquist and Bob Ferris
Prince Rupert - Rod Garbutt and Alan Stewart
Vancouver- Nick Humphreys and Dennis Clarke
Yukon Territory - Rod Turnquist

Other staff of the Forest Insect and Disease Survey project in 1988 were:

Allan Van Sickle - Head, Forest Insect and Disease Survey
Colin Wood - Chief Ranger
Joan Strobbe - Secretary
Lee Humble - Entomologist - Insectary and collection
Bob Duncan - Insectary Technician - diagnostics
Erika Pass - Insectary Technician - rearing and data base
Al Funk - Mycologist - disease identification
Daphyne Lowe - Herbarium Technician

Summary

The following is a summary of the pests most prominent in 1988 and most likely to be of interest and concern. Equally significant in terms of losses but not reported are several forest diseases such as root rots, dwarf mistletoes, stem decays, rusts, and cankers. Once established, these are perennial and fluctuate little from year to year and annual surveys are neither practical or necessary. Controls for such diseases are most practical as preventative treatments combined with stand management practices during the harvest-regeneration phase or juvenile stand tending. Also not included are impacts such as nursery and regeneration losses, aesthetics, increased fire hazards, or losses from white pine blister rust.

Successful overwintering survival and development of forest insect populations throughout the year resulted in very little overall change in the status of most major forest pests.

The most damaging forest pest in British Columbia was **mountain pine beetle**, which killed an estimated 3 million m^3 of mature pine in 8558 infestations which covered about 63 000 ha in six forest regions from near the international border southeast of Cranbrook to north of Terrace. Populations are forecast to continue in 1989. Infestations expanded in the Cariboo and Nelson regions and declined in the Kamloops, Prince George, Prince Rupert, and Vancouver regions. **Pine engraver beetles** and **lodgepole pine beetle** were common mostly in predisposed trees but were less numerous than in 1987 except in the northern part of the Prince Rupert Region, where lodgepole pine beetle killed pine adjacent to previously infested fire-scorched trees. **Pinewood nematode** populations remained extremely low with only individual predisposed trees affected at a few widely distributed locations. Woodborers which are potential vectors were collected. Discoloration of new pine shoots by **pine needle sheathminer** in the southern interior and southwestern coastal areas declined. Infection of year-old and older needles by **pine needle diseases** was common for the second consecutive year in the interior and in the southeastern part of the Vancouver Region. Quarantine-related surveys for **Scleroderris canker** and **European pine shoot moth** were negative for the canker and confirmed the establishment of the shoot moth only in ornamental pines in localized urban areas.

The area of Douglas-fir defoliated by **western spruce budworm** declined by more than half to about 360 000 ha, mostly in the Kamloops Region. **Douglas-fir tussock moth** larvae and pupae were found at Kamloops for the first time since 1983; a few egg masses were found at 14 locations, mostly west of Kamloops and near Hedley. Pockets of Douglas-fir killed by **Douglas-fir beetle** and **Armillaria root disease** were common in the East Kootenay part of the Nelson Region and were also present to a lesser degree in parts of the Cariboo and Vancouver regions.

Numbers of mature and overmature spruce killed by **spruce beetle** continued to decline for the sixth consecutive year in higher-elevation interior stands; however, beetle broods are maintained in windthrow in widely scattered parts of the province, most commonly in the East Kootenay. Mortality of spruce terminals by **spruce weevil** was widespread in young stands and highest in west coastal areas of Vancouver Island and in the western part of the Prince Rupert Region. Defoliation of coastal Sitka spruce by **spruce aphid** declined; however, mortality of trees on the Queen Charlotte Islands, severely defoliated for several successive years, remained at 67%. **Spruce bud insects** infested Sitka spruce in the western part of the Prince Rupert Region for the third consecutive year.

Alpine fir and white spruce north and west of Fort Nelson were defoliated by 1-year-cycle **eastern spruce budworm** over 36 000 ha, 40% less than in 1987. Mature **2-year-cycle budworm** defoliated new shoots of alpine fir and spruce in 490 separate infestations over 102 165 ha in the Cariboo, Kamloops, and Prince George regions, more than double the area defoliated in 1987, the "non-feeding" year. Immature "off-year" **2-year-cycle budworm** infested alpine fir and spruce in ten drainages in the Nelson Region and one in the Kamloops Region. Recent mortality of mature alpine fir in the province by **western balsam bark beetle** was mostly in the eastern part of the Prince Rupert Region where there has been a long history of losses from the beetle.

After three consecutive years of outbreak, defoliation of western hemlock on the Queen Charlotte Islands by **western blackheaded budworm** declined to only 10 ha at Tow Hill on northern Graham Island. **Hemlock**

sawfly populations also declined by about half but defoliated hemlock mostly lightly over about 7350 ha. Budworm populations near Holberg on northern Vancouver Island increased and defoliated hemlock over about 4830 ha, up from 5 ha in 1987. In the eastern part of the Prince Rupert Region, budworm populations defoliated new alpine fir shoots over 58 670 ha. After only 1 year of infestation, **western hemlock looper** populations in mixed hemlock, cedar, and maple at Jervis Inlet in the Vancouver Region collapsed, probably due to egg parasitism. Hemlock predisposed by dwarf mistletoe infections and understory trees were killed.

Larch casebearer populations in western larch in southeastern British Columbia were at relatively low levels similar to those in 1987. Numerous pockets of lightly or moderately defoliated larch were widespread in the Nelson Region but less common in the eastern part of the Kamloops Region. Casebearer parasitism increased 11% to a mean of 29% (range 0 to 82%) at 22 permanent study sites across the southern part of the Nelson Region where 1989 defoliation is forecast to be light at five sites and negligible at the other sites. Defoliation of western larch by **larch sawfly** increased for the first time since 1967 in the West Kootenay but declined following several years of fluctuations in the East Kootenay to 400 ha. Populations west of Watson Lake in the Yukon Territory defoliated tamarack for the second consecutive year but declined in the northern part of the Prince Rupert Region. Exotic larch in the University of British Columbia Research Forest near Haney and at Terrace were defoliated for the second consecutive year and in the City of Prince George for the first time in more than 20 years. Surveys for the potentially damaging **European larch canker**, currently limited to eastern North America, were negative for the eighth consecutive year. Infections of western larch by **larch needle diseases** were down significantly following 2 years of moderate and severe infection.

Conifer seedlings and herbaceous ground cover were severely defoliated and some planting programs were delayed by increased **black army cutworm** populations in wetter parts of the Nelson and Prince Rupert regions from the northern part of the East Kootenay to north of Kitwanga. Populations declined in previously infested areas in the Nelson Region but are forecast to continue in 1989 near some currently infested areas. Seedling mortality linked to infection by **Rhizina root disease** occurred for the first time in nearly 20 years in recent burns in wetter parts of the Nelson and Prince Rupert regions and for the first time in the Prince George Region.

Losses of moderate to heavy spruce and Douglas-fir cone crops due to cone and seed pests were significant for the second consecutive year, particularly in the interior. **Inland spruce cone rust** infected up to 100% of the spruce cone crop at 19 locations across British Columbia, mostly in the northern part of the Prince Rupert Region and to a lesser extent in parts of the Nelson Region. **Spruce cone maggot** and **spruce seed moth** were also common. Up to 25% of the Douglas-fir cones or seeds in the southern interior and in parts of the Vancouver Region were destroyed by a **seed chalcid**, **cone moth**, and **fir coneworm**.

Surveys of 129 young conifer plantations and natural stands across the province found the highest weevil-caused mortality of Sitka spruce leaders in west coastal areas of Vancouver Island and south of Terrace. **Pine terminal weevil** killed up to 12% of the leaders in 16 of 59 interior young pine stands. **Root collar weevil** killed 1% and infested up to 76% of the pine in 15 weevil-infested plantations less than 20 years old. Recently planted pine and spruce seedlings were damaged and some killed, by increased numbers of **hares** and declining numbers of **voles** in the western part of the Prince Rupert Region; vole populations declined in the eastern part of the region.

Increased mortality and upper crown dieback of mixed-age conifers across British Columbia, particularly in drier interior and south coastal areas, was attributed to cumulative **drought** conditions during 1985-87.

Pests of deciduous forests were generally common and widespread for the third consecutive year. **Forest tent caterpillar** severely defoliated trees and shrubs over 51 870 ha in parts of the Cariboo and Prince George regions and in the East Kootenay, but populations declined in the West Kootenay and in the Kamloops Region. **Western tent caterpillar** populations in southwestern British Columbia declined to endemic levels but high numbers of larvae severely defoliated trees and shrubs in the Bella Coola Valley for the second consecutive year and in the West Kootenay for the first time in 10 years. In addition, small numbers of colonies were common in the Okanagan Valley. Only 12 adult male **gypsy moths**, down from 216 in 1987, were trapped in British Columbia this year, including near Sicamous, Kelowna, West Vancouver, Coquitlam, Point Roberts, Colwood, and Parksville. Periodic effective control programs following trapping and egg-mass searches have prevented the establishment of populations in British Columbia. Poplar stands near Chilliwack and Harrison Hot Springs were severely defoliated by increased **satin moth** populations, the first infestation

in the Vancouver Region since 1975; populations in the Kamloops Region collapsed. **Western winter moth** populations increased in a second year of infestation in the southeastern part of the Vancouver Region and in the Shuswap and North Thompson river drainages of the Kamloops Region but declined in the eastern part of the Cariboo Region. **Winter moth** populations mainly on Garry oak on southeastern Vancouver Island remained very low for the fourth consecutive year. **Leaf blotch** of dogwood was more widespread and severe in southwestern British Columbia. Collection of **European mistletoe** in Victoria was a first Canadian record and only the second for North America.

Pine Pests

Mountain pine beetle

Dendroctonus ponderosae

The mountain pine beetle continues to be the most damaging forest insect in British Columbia. The area and volume of lodgepole pine and some western white pine killed by the beetle declined 5% from 1987 to the lowest level since 1977. Still more than 8550 active infestations (separately mapped polygons) cover nearly 63 000 ha (Map 1) from the international border to northeast of Prince Rupert (Table 1). This is more than six times the area burned by forest fires in British Columbia in 1988 and the volume lost (2.98 million m^3) represents about 15% of the lodgepole pine harvested each year in British Columbia.

Active infestations continued throughout the six forest regions in British Columbia. In the Cariboo Region a new infestation at Chilko Lake near the Coast Mountain Range expanded to 1300 ha. Elsewhere, recently killed mature pine were observed during aerial surveys in the Kamloops Region (17 650 ha, down 10% from 1987), the Nelson Region (26 180 ha, up 12%), in the Prince George Region (down 8% to 3975 ha), in the Prince Rupert Region (down 30% to 12 975 ha) and the Vancouver Region (down 40% to 845 ha).

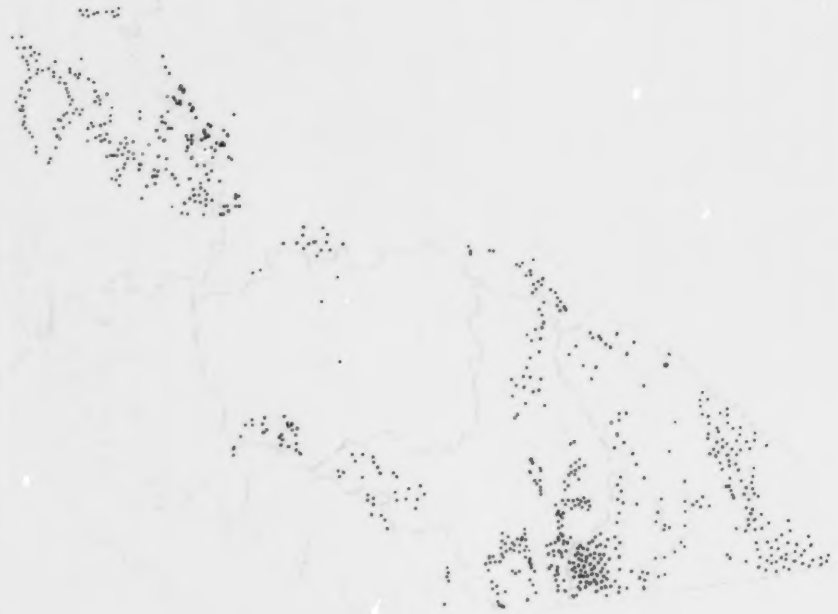
Mortality of overwintering broods in British Columbia was generally less than 10%. At 75% of the 42 locations sampled, the ratios of progeny to parents were greater than 4.0, indicating increasing populations for flight and attack in July. The highest average regional R value was in the Kamloops Region at 7.5 (range 0 to 37) mostly in the Okanagan Timber Supply Area (TSA). Values in the Prince George Region decreased to 4.2, but in the Nelson and Prince Rupert regions R values were similar to those in 1987 at 6.9 and 3.7, respectively. Near Pemberton in the Vancouver Region values declined to 2.0, where host availability is declining.

New infestations near Chilko Lake in the Cariboo Region expanded to 1300 ha in 230 separate pockets in the Franklyn Arm area, up nearly threefold from 1987, the first year the infestation was recorded. Elsewhere in the region, pine mortality remained low since the collapse of infestations, particularly in the western part. Cruises in 2-year-old infestations near Chilko Lake found 13% of the stems newly attacked by mountain pine beetle, indicating continuing populations in the area in 1989. No new attacks were observed elsewhere in the region.

In the Kamloops Region the area of mature pine killed by the beetle in 1988 declined slightly from 1987 and contained about 3.6 million trees (1.8 million m^3). Although pockets of 5 to 50 pine recently killed by beetles persist in widely scattered areas, the decline occurred mainly in the Lillooet TSA, where most susceptible mature pine has been killed in infestations active since 1972. Elsewhere in the region infestations continued, some for the twelfth consecutive year, in the Okanagan TSA and to a lesser extent in the Merritt TSA, including east of Kelowna from Daves Creek to McCullough and Little White Mountain, and east of Penticton at Saunier, Dale, and Sterling Creek drainages. West of the Okanagan Valley, infestations continued in Trout, Spukunne, Siwash, and Jellicoe creek drainages. East of Vernon mortality was scattered in pockets from Aberdeen Lakes into the Kettle River drainage. Groups of 5 to 10 beetle-killed white pine were more numerous than in 1987 from Vavenby to Albreda in the Kamloops TSA and near Barriere lakes. Tree mortality, mostly in the southern part of the Okanagan TSA, is forecast to

Map 1
Mountain pine beetle
1988

Areas where recent tree mortality was detected during aerial surveys.



BRITISH COLUMBIA

0 100 200 km

Forestry Canada / Forest Insect and Disease Survey

Table 1. Number, area and incidence of new and old attack of mountain pine beetle by forest region, based on recently killed trees recorded by aerial and ground surveys in British Columbia in 1988.

Forest Region	Number of infestations	Area (ha)	Trees killed[a] No. (000)	Trees killed[a] Vol. (000 m³)	Stands cruised[b] No.	Stands cruised[b] Avg. yrs. infested	Damage category[c] H C R G P —% of trees—
Cariboo	230	1300	265	23	1	2	47 13 24 10 6
Kamloops	1441	17 650	3569	1785	8	4	76 10 5 3 6
Nelson	4767	26 180	1255	455	17	6	49 28 12 10 1
Prince George	755	3975	100	72	4	5	55 11 27 6 1
Prince Rupert[d]	1297	12 975	1013	632	6	7	61 12 19 6 2
Vancouver	68	845	21	15	4	7	41 3 43 9 4
Total	8558	62 925	6223	2982	40		55 13 17 12 3

[a]Trees attacked in 1987, discolored in 1988.

[b]Some stands located in younger infestations may not represent average condition.

[c]H - Healthy; C - Current, attacked in 1988, R - Red, attacked in 1987, G - Grey, attacked in or before 1986; P - Partial or strip attacked in 1988.

[d]Estimates include data from the British Columbia Forest Service.

increase slightly to 10% in 1989. This is based on cruises in eight stands infested on average for 4 years.

Infestations in the Nelson Region increased 10% in area to 26 180 ha which contained about 1.2 million trees (455 000 m³). Increases occurred in the Cranbrook and parts of the Invermere TSAs in the East Kootenay from the U.S. border north to Steamboat Mountain. Tree mortality in the White River drainage declined. For the third consecutive year infestations in the Boundary TSA expanded, but there was little change in the Arrow, Kootenay, and Revelstoke TSAs. Infestations along the British Columbia-Alberta border and in Glacier and Yoho National Parks declined for the third consecutive year but continued in Kootenay National Park at levels similar to 1987. There were major concentrations of past and current attack south of Daer Creek and Redstreak Mountain, with smaller patches from the south park border to Hector Gorge. New attacks in the region increased by 15% to an average of 28% in 17 stands infested from 2 to 12 years. Current attack was highest (average 41%) in six areas in the East Kootenay including Bloom Creek, Bull River, and Steamboat Mountain. In the West Kootenay new attacks were 41% at Eholt Creek and 25% or more in the Boundary, Ingram, Crouse, and Carmi creeks.

The area containing recently killed pine in the Prince George Region declined less than 10% to 3975 ha in 755 separate infestations which contained about 100 000 trees (72 000 m³). Most of this area was northwest of Fort St. James in the Skeena, Sustut, and Middle river valleys, near Takla and Trembleur lakes, and in Tree Farm License (TFL) 42. Smaller infestations continued southwest of Prince George and southeast of Valemount but declined southwest of Vanderhoof and east of Prince George where cut-and-burn operations have contributed to the reduction in beetle populations. Recent ground surveys by the British Columbia Forest Service in Mt. Robson Provincial Park and west of Jasper

National Park located about 60 mountain pine beetle-attacked trees including 47 baited trees. Cut-and-burn control operations since 1985 have removed over 500 beetle-killed pine. New attacks in standing green mature lodgepole pine in four stands in the Fort St. James area averaged 11%, indicating continuing pine mortality in 1989 but less than in 1988.

Pine mortality in the Prince Rupert Region declined 30% to 12 975 ha, following 2 years of increase; this area contained 1 million trees (632 000 m^3) in more than 750 separate infestations. The decline was mostly in the eastern part of the region in the Morice River drainage including Harold Price Creek and in the Nilkitkwa River Valley. The decline was due to aggressive cut-and-burn operations and reduced population vigor, and in part to variable mapping techniques. Pine mortality was down slightly in the Kitwanga and Cranberry Junction area in the western part of the region, but increased slightly elsewhere in the Nass, Skeena, and Cranberry river valleys. Mortality in the Prince Rupert Region is forecast to decline in 1989 to 10% (range 4 to 25%), two-thirds less than in 1988; this prediction is based on cruises in six stands infested for an average of 7 years.

An estimated 9000 mature lodgepole pine in the northern part of the Prince Rupert Region, adjacent to previously infested pine partially burned by forest fires in 1982, were killed by increased numbers of lodgepole pine beetle, *Dendroctonus murrayanae*, and engraver beetles, *Ips* spp. Single trees and pockets of 5 to 10 and occasionally groups of up to 50 were scattered throughout 5800 ha mostly between Dease Lake and Cassiar and to a lesser extent south of Lower Post. Other secondary beetles, *Hylurgops porosus* and *H. rugipennis*, were common at the root collars. Beetle populations are not expected to attack or kill significant numbers of adjacent green standing trees due to their preference for predisposed trees including fire-scorched pine.

Pine mortality in the Vancouver Region declined overall by nearly half to 845 ha and 21 000 trees (15 000 m^3). The decline was in the Homathko River drainage in the Sunshine Coast TSA where little susceptible host material remains following 7 years of recorded infestations. Pockets of tree mortality increased slightly in the Fraser Canyon and in the Lillooet Lake drainage and continued in small long-term infestations near Pemberton. Current attack in four stands previously infested for about 7 years in the Lillooet TSA averaged 3%.

In summary, infestations will continue in all regions in 1989. The frequency of new attacks on mature lodgepole pine in 40 previously infested stands cruised in six forest regions ranged from an average of 3% in the Vancouver Region to 28% in the Nelson Region with a province-wide average of 13%. In all four of the six regions the ratio of the number of currently attacked trees to the number attacked last year is less than one, with an average of 1:0.8.

Secondary bark beetles, particularly *Ips* spp., and to a lesser degree *Dendroctonus murrayanae* were common for a third consecutive year in parts of the Cariboo, Nelson, Prince George, and Prince Rupert regions.

Operational control of bark beetles involved harvesting of susceptible stands, salvage logging, trap tree programs, single tree treatments of cut and burn, debarking, and pre-adult post-attack injection with the silvicide MSMA. Redirection of logging operators particularly into the Okanagan Valley drainages due to expanding infestations resulted in increased transportation costs.

Pinewood nematode

Bursaphelenchus xylophilus

Based on more than 1000 samples from trees and potential vectors collected by Forestry Canada from throughout British Columbia since 1983, incidence of this nematode remains extremely low in forests; only individual, predisposed trees are affected at a few widely distributed locations. Examinations of chip piles at 11 mills during optimum insect flight times and weather conditions in 1988 found only three possible vectors at two mills. Similar collections from slash piles and log decks resulted in 208 potential vector beetles being captured. Of these insects, 78 were three different species of *Monochamus*, 19 were *Buprestis*, 7 were *Pissodes*, 12 were *Cylindrocopterus*, 36 were *Hylurgops*, and 25 were *Dendroctonus*. Nematode extraction and identification are in progress.

Pine needle sheathminer

Zelleria haimbachi

Sheathminer populations in lodgepole pine stands in previously infested stands in parts of the Kamloops, Nelson, and Vancouver regions declined overall to about 1000 ha in about 15 separate areas. This followed 2 to 3 successive years of moderate to severe defoliation.

In the Kamloops Region new shoots on groups of 2 to 10 lodgepole pine over about 575 ha were lightly discolored for the first time near Pritchard and northeast of Kamloops. Previously infested lodgepole pine near

Salmon Arm were moderately and severely discolored in three patches totalling 135 ha; the most severely damaged patch was at Syphon Creek which has sustained damage for four consecutive years. Two to five percent of the branches of young lodgepole pine in three seed orchards in the north Okanagan were lightly discolored for the first time. Semimature ponderosa pine in Skihist Provincial Park near Lytton were lightly to moderately discolored by increased sheathminer populations.

New shoots on mostly immature lodgepole pine over 235 ha at Gibbs Creek in the West Kootenay were discolored for the second consecutive year and discolored pine were again common along roadsides between Greenwood and Grand Forks. Populations near Kaslo declined after 2 years of infestation. In the East Kootenay, discoloration of pines between Yahk and Cranbrook, common in 1986 and 1987, was negligible this year. Increased populations very lightly discolored young lodgepole pine over 200 ha near Spillimacheen and near St. Mary Lake west of Kimberley.

Discoloration of pine regeneration in the Vancouver Region by the sheathminer occurred in some parts for the third consecutive year but less severely and less extensively than in 1987. On the east side of Lillooet Lake an average of 10% of the new shoots were discolored. Similar declines occurred in pockets of 20 to 55 ha near Keefers and on the west side of Harrison Lake where defoliation occurred for the first time in 1987.

Although assessments of overwintering populations were insufficient to allow accurate forecasts for 1989, sheathminer populations usually decline after 2 years in a stand. Infested pine usually recover following successive years of defoliation.

Pine needle diseases

Lophodermella concolor
Dothistroma pini
Elytroderma deformans

Infection of new and older needles of lodgepole, ponderosa, and white pines by native needle diseases was common in parts of the Nelson and Kamloops regions and in the Yukon Territory, and increased in the Cariboo Region.

Severe (70 to 95%) infection of year-old and older needles of lodgepole pine by *Lophodermella concolor* was again common in the southern part of the Cranbrook district in the Nelson Region. Discolored 1-year-old needles were common also in lodgepole pine stands in the Kamloops Forest Region from near Manning Park to Gold Bridge and throughout the Okanagan Valley drainages.

Infection of year-old needles by *Dothistroma pini* on immature white pine declined in a long-term assessment plot at Summit Lake near New Denver in the Nelson Forest Region. Consecutive years of infection have resulted in premature loss of all the needles in the lower crown and thinning of the upper crown. Increased infection of young western white pine occurred between Shelter Bay and Revelstoke where 5 to 70% (average 30%) of the trees were infected. Infected white pine were less common south of Shelter Bay to Nakusp and in the Slocan Valley.

Infection and brooming by *Elytroderma deformans* were common in ponderosa pine stands in the Kamloops and Cariboo regions, where stands are infested for the fifth consecutive year. Infections ranged from light to severe in patches, and over areas of several hundred hectares from Monte Lake to Gold Bridge, in the North Thompson River Valley, from Kelowna to Osoyoos, and west of Princeton. New infection of lodgepole and ponderosa pine stands was widespread in the Cariboo Region. Discoloration mostly in the lower crowns of most trees occurred in areas of 0.5 to 100 ha west of Williams Lake and in the 100 Mile House, Williams Lake, and Clinton areas.

A needle blight, *Davisomycella montana*, infected 15% of the 2-year-old and older needles of lodgepole pine along the lower Canol Road and near Rancheria in the southern Yukon Territory. This was the first record of this pathogen infecting lodgepole pine in the Territory. Winter flecking which caused discoloration and premature casting of older needles was also common in both areas and in the Takhini Forest Reserve near Whitehorse, between Johnsons Crossing and Jakes Corner, and near Tarfu Lake on the Atlin Road.

Scleroderris canker

Gremmeniella abietina

Examinations of native lodgepole, ponderosa, and whitebark pine at four locations in British Columbia, where the North American strain of this fungus was previously collected, were unable to relocate the fungus. Surveys of native pines elsewhere throughout British Columbia were also negative. This important pathogen, a strain of which has caused extensive mortality of young pines in plantations and nurseries in eastern Canada and the United States, was rare and only found as a lower branch saprophyte in British Columbia between 1968 and 1978 near Penticton, Canal Flats,

Castlegar, and Kimberley.

European pine shoot moth
Rhyacionia buoliana

Surveys of interior native and exotic pines were initiated and three pheromone baits in sticky traps were tested at five interior and six coastal sites to determine the status of the shoot moth since provincial quarantine regulations lapsed in 1981. Survey results indicate that the shoot moth is established in localized urban areas including Victoria, the Lower Mainland, and the Okanagan Valley, but the areas have not increased in number and there is no evidence of shoot moth populations in native pines.

The highest average numbers of moths per trap were at Penticton (33), Richmond (20), Kelowna (18), Ladner (11), Cloverdale (6), and Victoria (6). The three pheromones tested averaged 12, 8, and 6 moths per trap. But because of the large variability and the small sample (60 traps), trapping results were not significantly different. New shoots of exotic pines at two sites in Nanaimo were infested and 5% of the shoots were infested on 35% and 100% of the exotic pines at sites in East Vancouver and Delta. Surveys for the shoot moth at the Peace Arch in the Vancouver Region, at seven sites from Sooke to Campbell River, and near Castlegar and Prince George, were negative.

Douglas-fir Pests

Western spruce budworm
Choristoneura occidentalis

After three successive years of expansion, the total area of defoliation of mixed-age Douglas-fir by western spruce budworm declined to 359 670 ha in the southern interior of British Columbia (Map 2). This is less than half the area affected in 1987. More than 1220 areas were aerially sketchmapped and of these 96% were in the Kamloops Region, 2% were in the Cariboo Region, and 1% were in each of Vancouver and Nelson regions. The intensity of defoliation also declined; defoliation was light on 83% of the area, moderate on 16%, and severe on 1%.

Severe defoliation covered 3400 ha mostly in the Shuswap Lake area, and near Vernon, Kelowna, and Penticton. Moderate defoliation was mapped over 60 000 ha in 184 infestations, mostly in the Kamloops Region and to a lesser extent in the Vancouver Region, and light over the remainder.

Of the total area infested since 1983, 48% has been defoliated for 1 year, 36% for two consecutive years, and 15% for 3 or 4 years. Only 1% has been defoliated for five or six consecutive years.

The greatest areas of decline occurred in the Lillooet and Kamloops TSAs including the Clearwater District and in the eastern part of the Cariboo Region. Infestations in the Okanagan Valley as well as those in the southwestern part of the Nelson Region and near Pemberton in the Vancouver Region expanded slightly.

Parasitism of early- and late-instar larvae occurred at all 26 sites sampled and averaged 16% (range 1 to 54%); this level of parasitism is similar to that found in 1987, but it is still too low to effectively reduce populations. The cause of the decline has been attributed to larval starvation in chronically infested areas and possibly to the depletion of nutrient reserves of early-instar larvae following emergence during a prolonged warm dry fall in 1987.

Egg sample assessments at 52 locations in four regions indicate light to moderate defoliation in 1989 in most areas (Map 3). However, defoliation is still forecast to be severe at 10 of the sites (of which six are in the Nelson Region), moderate at 16 sites, light at 21 sites, and absent at five sites. Egg masses were, on average, 70% less numerous at 28 of the 36 locations sampled in both 1988 and 1987, and more numerous at only eight locations. Increases were noted in the following areas: in the south Okanagan at Equesis Creek, Glenrosa and Mt. Kobau; in the Nelson Region at Anarchist Mountain, McKinney Creek and Conkle Lake Road; in the Cariboo Region at Viewland Mountain; and in the Vancouver Region at Devine.

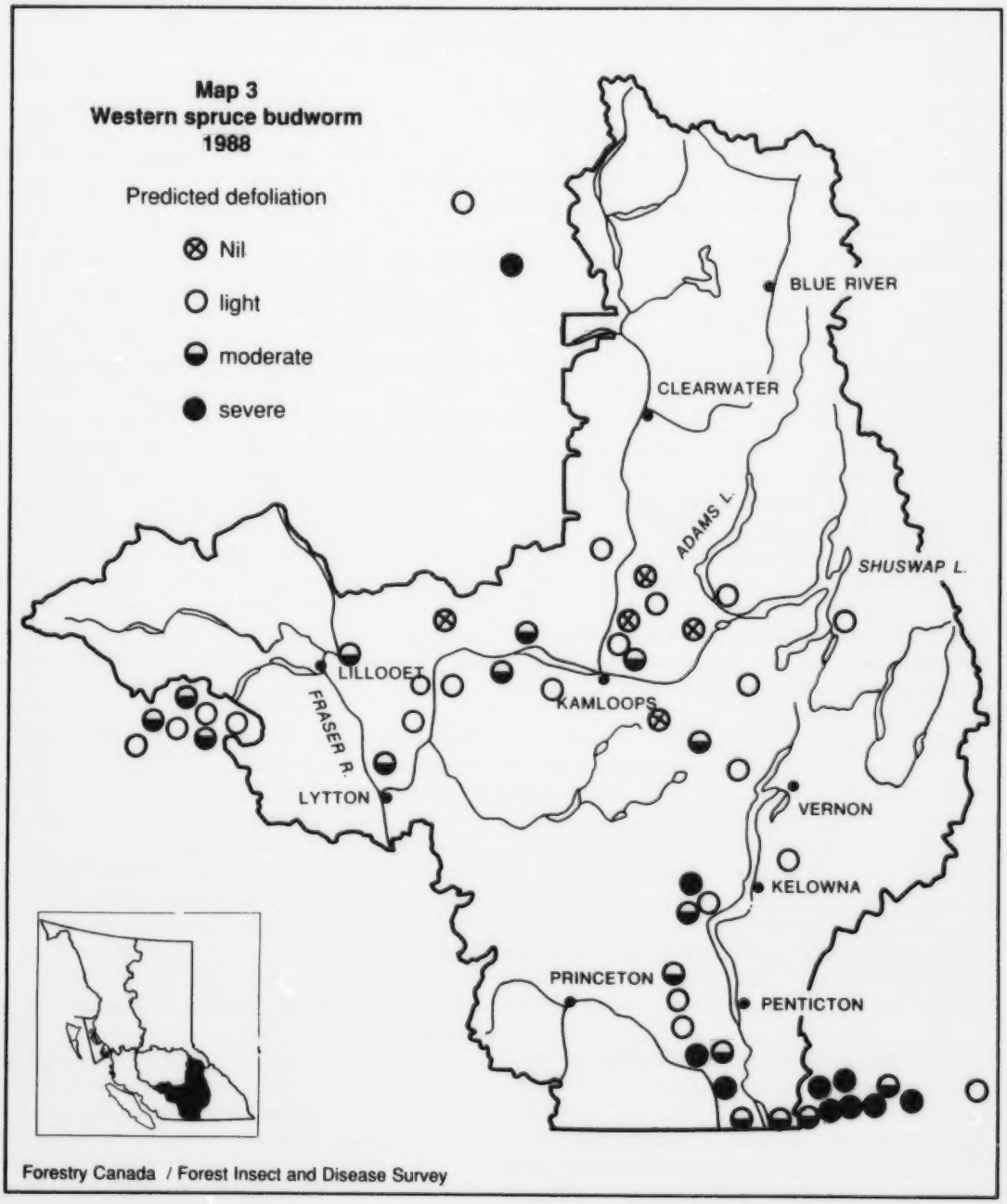
KAMLOOPS FOREST REGION

0 40 80 km

Map 2
Western spruce budworm
1988

Areas where current defoliation was detected during aerial surveys

Forestry Canada / Forest Insect and Disease Survey


Map 3
Western spruce budworm
1988
Predicted defoliation
Nil
light
moderate
severe
BLUE RIVER
CLEARWATER
ADAMS L.
SHUSWAP L.
LILLOOET
KAMLOOPS
FRASER R.
LYTTON
VERNON
KELOWNA
PRINCETON
PENTICTON
Forestry Canada / Forest Insect and Disease Survey

Tree mortality and growth loss is variable. Continued monitoring of long-term study plots in open-growing Douglas-fir near Cache Creek indicates that tree mortality averaged 30 to 40% in 1987, 1 year after collapse of the infestation in these stands. Decline in diameter increment in mature trees occurred 1 or 2 years after the first year of defoliation in 1979, and increment has been almost nil since 1982. Monitoring continued in 64 research plots established in young, open-growing Douglas-fir. These plots were established in 1986 in areas which had sustained 0 to 7 years of defoliation. As of 1988, tree mortality averaged 4.9% but varied widely (from 0 to 75%). A trend of increasing mortality with increasing number of years of defoliation is apparent. Greater damage exists where regeneration is overtopped by older trees and mortality is often high (R. Alfaro, Forestry Canada, Victoria, personal communication).

Operational aerial spray trials of *Bacillus thuringiensis* (*B.t.*) were applied by the British Columbia Forest Service over a total of 1800 ha including five new areas in the Kamloops Region, one in the Nelson Region, and 11 blocks in the Kamloops Region sprayed in 1987. Preliminary spray results are variable due to highly varied larval development and bud flush, and natural reduction of up to 80% of populations in 8 of 11 plots. At Paul Lake Park, sprayed each year since 1986, population reduction was 80% and no current defoliation was apparent; however, egg masses, likely from neighboring infestations, indicate moderate defoliation in the area in 1989.

As part of a study to improve and calibrate detection methods for western budworm, mid- to late-instar budworm larvae and adult males were monitored in four regions at 12 sites with a history of budworm outbreaks, but still with low populations. Up to 32 larvae/tree were collected per 1 m^2 beating (3 branches on 25 trees/plot) and up to 680 male adults were caught in a total of 57 Multipher® traps. Further analysis and additional sampling is necessary before numbers can be correlated with population potential and damage.

Douglas-fir tussock moth

Orgyia pseudotsugata

For the first time since the last outbreak collapsed in 1985, tussock moth larvae, pupae, and egg masses were reported on Douglas-fir trees in urban Kamloops. Relatively few egg masses were collected at 13 sites in the Kamloops Lake area and one near Hedley in the southern Okanagan and on two newly defoliated ornamental spruce in Victoria. An infestation is not expected in 1989.

Pheromone-baited sticky traps continue to be placed in 17 Douglas-fir stands selected for the greatest historical frequency of outbreaks in the Kamloops Region. The number of male adults trapped increased for the third consecutive year to 1717 adult males in 84 of 130 traps at 38 of 51 sites. This is up from 387 adults in 45 traps and 75 adults in 25 traps in 1987 and 1986, respectively. Numbers decreased in the Nelson Region with only one adult per trap at one of two locations; in 1987, four and seven adults per trap were caught at the same two locations.

Increasing trends over 2 or 3 years or an average catch of 25 or more male moths per trap per location indicates potential visible defoliation within two summers. Trap catches reached this level near Kamloops and in the Okanagan Valley in stands near Winfield, Vernon, and between Savona and Pritchard. Egg mass surveys in these areas indicate increasing populations and potential for defoliation in 1990. An average of three egg masses were found at 13 sites surveyed over about 1000 ha in the Kamloops Lake area and near Hedley (total 40). All but two masses were found on single trees during the survey which took approximately 100 hours. The highest number per site was at the Beaton Ranch south of Kamloops Lake where 10 and 4 egg masses were found at two sites, and east of the Ranch on the Dominic Lake road where nine new egg masses were found at one site. None was found at nine additional sites in the Kamloops area and seven in the Okanagan-Similkameen.

Additionally this year, single traps were located at intervals of 1 to 2 km between Deadman River and Cherry Creek, in the Pritchard area and near Winfield south of Kamloops to help delineate the distribution of the moth. Traps were also placed by British Columbia Forest Service personnel in scattered locations throughout the southern half of Kamloops Region to augment Forestry Canada's research and monitoring. Results also indicate increasing populations.

Mortality of Douglas-fir was related to severity and duration of defoliation on 61 plots defoliated by tussock moth from 1982 to 1985 (R.I. Alfaro, Forestry Canada, Victoria, personal communication). Stands with severe defoliation sustained 66% tree mortality and 17% of the survivors were top-killed.

Douglas-fir beetle

Dendroctonus pseudotsugae

For the second consecutive year, widely scattered pockets of up to 40 mature Douglas-fir trees killed by Douglas-fir beetle occurred in the Fraser River drainage in the

Cariboo and Vancouver regions and in the Nelson Region.

In the Cariboo Region most beetle-killed trees, in groups of 5 to 15, were along the west side of the Fraser River near Marguerite. Newly attacked trees were common near slash piles of Douglas-fir at Comer near Williams Lake. Small groups of one to three mature Douglas-fir were killed by the beetle in the Fraser Canyon between North Bend and Nahatlatch Lake; they were probably weakened by maturity and root disease in this area which has a long history of scattered beetle-related tree mortality. Groups of 2 to 40 standing beetle-killed Douglas-fir at Gold Creek in the Cranbrook TSA to Invermere were associated with drought stress and root disease. Current attacks indicate increasing populations in numerous groups of Douglas-fir in the Gold, Bloom and Wildhorse Creek areas and near Whiteswan Lake.

Armillaria root disease

Armillaria ostoyae

Armillaria root disease infected and killed mature Douglas-fir in mixed stands in several areas examined in the Rocky Mountain Trench in the Nelson Forest Region. At Cariboo Creek on Bush Arm, 10 to 15% of the mature trees over several hundred hectares have been recently killed; mortality of 25 to 30% is common in small patches. At Sanca and Kidd creeks near Creston, 5 to 15% of the mature Douglas-fir were killed in pockets with larger centers around old stumps. In an undisturbed mixed stand in the Kootenay River Valley east of Canal Flats, 6% of the mature (100-year-old) Douglas-fir were infected and killed; 8% were infected and killed at Smallwood Creek near Nelson; and 6% of the immature Douglas-fir at Fitzstubbs Creek east of Nakusp were infected and killed. There was no evidence of diseased trees in a 65-year-old selectively logged stand in the Palliser River Valley.

Spruce Pests

Spruce beetle

Dendroctonus rufipennis

The area and volume of mature white and Engelmann spruce killed by the beetle in British Columbia declined for the sixth consecutive year. Host depletion, salvage, and sanitation contributed to the decline. Most of the 1675 ha of infested spruce mapped in aerial surveys were in about 20 separate infestations in previously infested stands, mainly in the Kamloops Region and to a lesser extent in the Nelson Region.

Recent mortality of mature spruce by spruce beetle in the Kamloops Region was confined largely to the Lillooet District in previously infested stands at Connel and McGillivray creeks. The infested areas declined to 10, totalling 1020 ha. Spot infestations of 10 to 15 trees occurred at North Kwoiek Creek west of Kanaka Bar in the Fraser Canyon. Older infestations in the Tulameen River drainage declined to 430 ha, primarily as a result of harvesting.

In the Nelson Region, populations largely in windthrow increased in the East Kootenay in seven areas totalling 225 ha from Creston to east of Golden. An average of six attacks in 500 cm^2 of bark samples (range 3 to 8) were common in fringe blowdown; the highest number of attacks were at Redding Creek west of Kimberley and in the Beaverfoot River Valley near Golden. Bolts of felled spruce at the southern boundary of Glacier National Park at the head of the Duncan River contained an average of seven adults in 500-cm^2 bark samples. These small broods have the potential to survive and attack standing and windthrown spruce in 1989.

Along the Haines Road in the Prince Rupert Region, felled lethal spruce trap trees and windthrow were again attacked by the beetle for a second consecutive year. Road construction in 1983 predisposed the trees to attack and contributed to population buildup. Through cooperative programs infested trees were removed or felled and peeled to prevent an outbreak, but successive years of windthrow are sustaining populations in the area.

Timely salvage, sanitation, and host depletion should

maintain present populations mostly in scattered windthrow, corridors, log decks, and butts of mature and overmature standing trees.

Spruce weevil

Pissodes strobi

The incidence of leader mortality by weevil attacks in 10- to 15-year-old Sitka spruce at 22 sites in the western part of the Prince Rupert Region averaged 24% (range 5 to 44%). The highest incidence was in the Copper, Skeena, and Kitimat river valleys including the Kalum Lake area where 20 to 44% of the current leaders were killed. At Cedarvale, Kitwanga, and the Nass River crossing an average of 6% of the terminals were killed.

In the interior, new attacks killed terminals on 3 to 35% (average 11%) of the spruce at six sites in the Nelson Region; the highest number of attacks was at Quartz Creek, and 5% of the trees were attacked near Tacheeda Lake north of Prince George.

New leaders of immature Sitka spruce were killed by the weevil at seven locations on Vancouver Island from Port Renfrew to Port Alice. The highest incidence (50%) was at Duncan Bay; at the other locations, an average of 7% (range 5 to 10%) of the terminals were killed. Current leader mortality of young Sitka spruce in plantations surveyed by the British Columbia Forest Service over more than 3000 ha in five areas between Nootka and Kyoquot sounds on the west coast of Vancouver Island was severe (more than 50% of the terminals killed) at three areas, moderate at one area, and light at one area. In the Nusatsum River Valley near Bella Coola, 28% of the leaders were attacked.

The search for natural enemies to control spruce weevil has continued with the importations of European parasitoids *Eubazus semirugosus* and *Coeloides sordidator*.

A computer simulation model to calculate the impact of the Sitka spruce weevil on log yield, based on long-term records from the Nitinat Lake area on Vancouver Island predicts volume losses of 1 to 62% can result at rotation with 1 to 30% of the trees attacked per year (R.I. Alfaro, Forestry Canada, Victoria, personal communication).

Spruce aphid

Elatobium abietinum

Despite a second consecutive mild winter, defoliation of new and older needles of Sitka spruce in northeast coastal areas of the Queen Charlotte Islands by the spruce aphid declined after an increase in 1987. Most old needles on young spruce at Skijump Creek on North Moresby Island were infested. At Miller Creek on Graham Island most new and old needles on 8-year-old Sitka spruce were lightly infested. Tree mortality in a nearby infested stand, studied since 1982, was 67%, the same as in 1987. Populations on the mainland coast south of Prince Rupert, the lower mainland part of the Vancouver Region, and on the east coast of Vancouver Island declined following a slight increase and variable intensities of defoliation in 1987.

Spruce bud insects

Acleris gloverana
Zeiraphera canadensis
Pineus spp.

For the third consecutive year new tips of young Sitka spruce in the western part of the Prince Rupert Region were infested by spruce bud insects. The long-term impact of successive years of infestation has not yet been determined. An average of 72% of the 8- to 18-year-old trees in 13 plantations in the Skeena, Kitimat, and Copper River drainages were infested mostly by spruce budmoth, *Zeiraphera canadensis*, and occasionally with western blackheaded budworm, *Acleris gloverana*. This is similar to 1987 and only 8% less than in 1986. Damage was most severe at Prudhomme Lake where more than 30% of the buds on about 13% of trees were infested. Elsewhere, 10% or less of the buds on most of the trees were infested. The incidence of seedlings infested at four additional sites ranged from 2 to 69% (average 29%); the highest incidence occurred in the Coldwater River Valley. Fourteen percent fewer trees (average 32%) were infested by a spruce gall adelgid, *Pineus* sp. than in 1987 in eight young Sitka spruce plantations.

True Fir Pests

Budworms

Choristoneura spp.

Alpine fir and spruce forests in three forest regions were defoliated by eastern and 2-year-cycle budworms over 36 000 ha and 102 185 ha, respectively (Map 4).

Current foliage of white spruce and alpine fir was lightly defoliated by eastern spruce budworm, *Choristoneura fumiferana*, over 36 000 ha in 130 separate infestations north and west of Fort Nelson in the northeastern part of the Prince George Region, a decline of 40% from 1987. Defoliation extended into the Northwest and Yukon territories. The decline was mostly in the Fort Nelson River Valley and at Kledo Creek, although the understory was severely defoliated. Defoliation declined to a lesser extent in the Cole and Smith River areas and at Liard Hotsprings. Three 50-ha seed collection blocks near Fort Nelson were aerially treated with *Bacillus thuringiensis* by the British Columbia Forest Service.

Defoliation of alpine fir and spruce forests by 2-year cycle budworm, *Choristoneura biennis*, was light or moderate over 102 185 ha in 490 infestations in three forest regions. This was more than double the area affected in 1987 which was largely a non-feeding year. The mature "on-year" cycle budworm larvae defoliated 42 250 ha in the Kamloops Region, 40 215 in the Cariboo Region, and 17 500 in the Prince George Region. Immature "off-year" cycle larvae infested higher-elevation alpine fir buds in 10 drainages in the Nelson Region.

The area of mostly light defoliation of new shoots of fir-spruce in the Kamloops Region more than doubled in 159 areas in the North Thompson and Adams river drainages. New infestations occurred north of Tranquille River and east of Bonaparte, McLure, and Hadlow lakes; light defoliation occurred north of Blue River. Four pockets of light defoliation totalling 1000 ha were mapped at Tsuius, Curwen and Tourmaline creeks east of Mabel Lake and in the Shuswap River drainage.

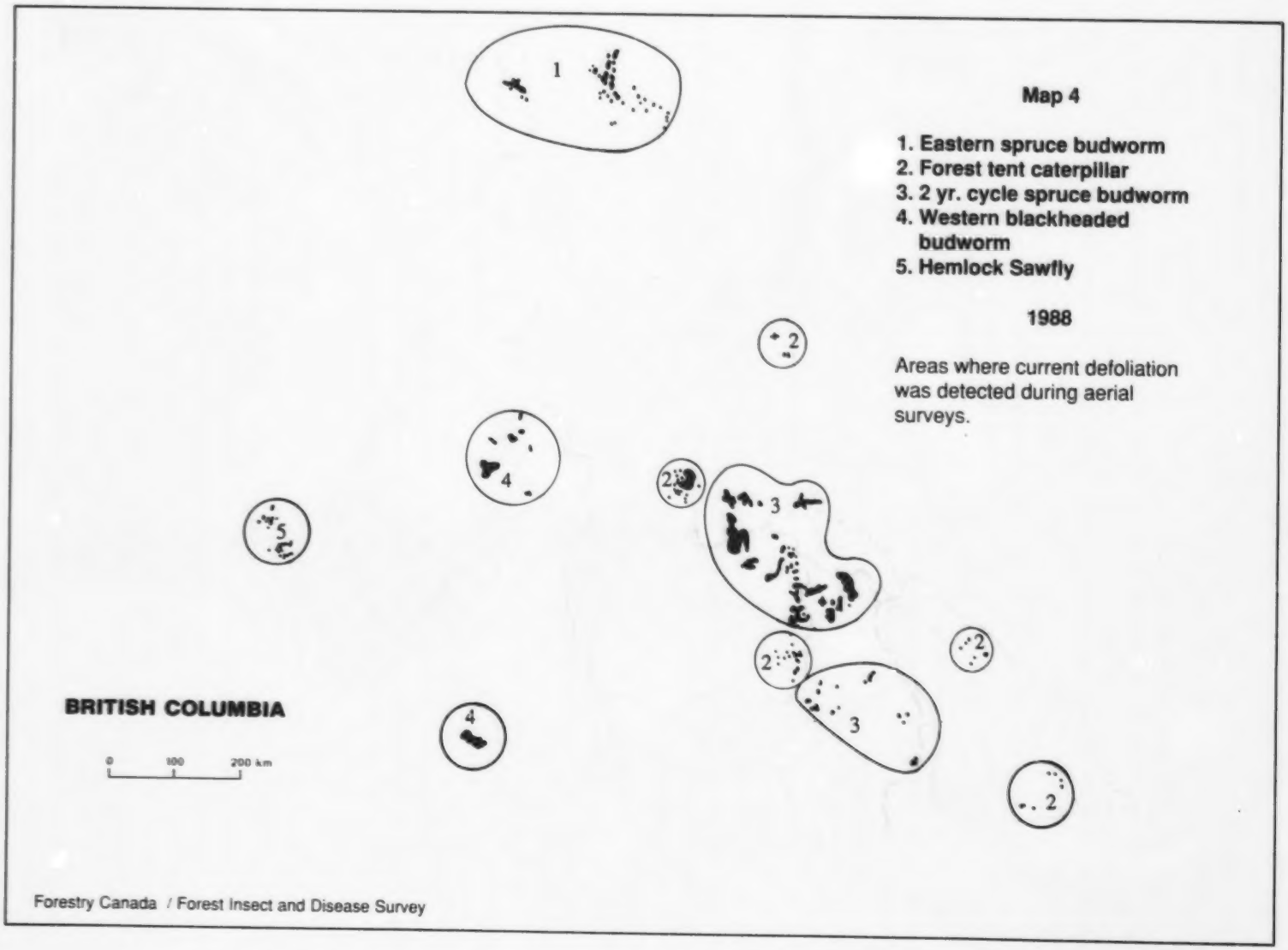
In the Cariboo Region defoliation of mature and immature Engelmann spruce and alpine fir in the northeastern part of the region increased nearly fourfold to 40 215 ha in 240 separate infestations. Defoliation was mostly light on 39 250 ha and moderate on the remainder. Most of the feeding occurred from Hendrix Lake east of Williams Lake to the Willow River north of Barkerville, especially in the Willow and Swift river valleys and at Big Valley and Tregillus creeks. Other areas of defoliation were in the Quesnel Lake area, including the North Arm, Matthew River, Mitchell Lake, Niagara Creek, MacKay River, Crooked Lake and Deception Creek.

In the eastern and southeastern parts of the Prince George Region, alpine fir and spruce were defoliated over 17 500 ha in the Everett and Ames creeks, Morkhill River, and Stoney Lake areas. Defoliation in 88 separate infestations by mature larvae was moderate over half the areas and light over the remainder. In 1987, there was mostly light defoliation by immature larvae.

In the Nelson Forest Region 2-year "off-year" cycle immature larvae infested 5 to 100% (average 31%) of the buds in seven higher-elevation stands in the East Kootenay and about one-quarter of the buds in three previously infested fir-spruce stands in the West Kootenay. Defoliation of new tips by maturing second-year larvae is forecast to occur in 1989 in the Cranbrook and Invermere TSAs at Baker and Redding creeks, and at Vowell, Bobby Burns, Dewar, and McMurdo creeks and at Plant, Airy and Barnes creeks in the Arrow Lakes TSA in the West Kootenay. Consecutive years of severe defoliation of alpine fir and spruce of intermediate age in the upper St. Mary River drainage at Dewar, Baker and Redding creeks has resulted in the loss of up to 90% of the foliage on half the trees. In the eastern part of the Kamloops Region populations increased in 15 pockets totalling 2200 ha at Keefer Lake in the Upper Kettle River Valley and lightly defoliated the current year's shoots.

Egg samples at 15 infested sites in the Kamloops, Cariboo and Prince George regions forecast high numbers of immature budworm larvae in new buds in 1989 in the Cariboo and Prince George regions, but fewer larvae are forecast in the Kamloops Region.

Larvae and adult male populations continued to be monitored in three regions to improve and calibrate methods to detect budworm populations in fir-spruce forests. Up to 34 adult males were collected in 13 non-


Map 4
1. Eastern spruce budworm
2. Forest tent caterpillar
3. 2 yr. cycle spruce budworm
4. Western blackheaded budworm
5. Hemlock Sawfly
1988
Areas where current defoliation was detected during aerial surveys.
BRITISH COLUMBIA
0 100 200 km
Forestry Canada / Forest Insect and Disease Survey

sticky Universal® traps at three locations. Further study, however, is necessary before numbers can be correlated with population damage and potential.

Balsam woolly adelgid

Adelges piceae

The status of quarantine regulation zones in southwestern British Columbia remains under consideration after the discovery in 1987 of adelgid populations on West Thurlow Island substantially beyond the regulation and infestation zones. Additional surveys within and outside the zones and along the international border in the Nelson Region have not found any significant new occurrence of the adelgid in 1988. Nearby in northern Idaho, adelgids are quite common in frost pockets with high numbers of stem bark attacks. Local predator recovery surveys continue and results will be reported later. Tests to determine effective control methods on seedlings continue.

Western balsam bark beetle

Dryocoetes confusus

Most of the mature higher-elevation alpine fir recently killed by the beetle-fungus complex in more than 535 pockets totalling about 62 450 ha was in the Prince Rupert Region, but some mortality occurred in all regions.

Infestations in the Prince Rupert Region which covered 57 700 ha in more than 240 separate infestations were mostly in the Morice TSA, near Ootsa, Whitesail, Troitsa and Nadina lakes and in northern parts of the Bulkley TSA west of Babine Lake, where chronic infestations have persisted for many years.

In the Prince George Region, alpine fir mortality was scattered in 54 infestations over 1220 ha, mostly northwest of Fort St. James. Significantly reduced aerial surveys, particularly over previously infested stands east of Prince George and Mackenzie, were a major factor in any apparent decline in area.

Areas containing recently killed mature alpine fir in the Cariboo, Kamloops, Nelson, and Vancouver regions covered 1230 ha, 45 ha, 1715 ha, and 545 ha, respectively, in more than 240 separate pockets. This was comparable to a total of 3000 ha in 1987.

The areas containing recently killed trees fluctuate annually; this is due in part to interpretations of the color of red needles, many of which are retained for at least 5 years on beetle-killed trees. Also, the level of importance, and hence the amount of flying time, varies considerably from region to region and year to year.

Hemlock Pests

Western blackheaded budworm and hemlock sawfly

Acleris gloverana and *Neodiprion tsugae*

Blackheaded budworm and hemlock sawfly populations declined after three consecutive years of feeding on the Queen Charlotte Islands. Western hemlock over about 7350 ha (Map 4) were defoliated mostly by sawfly populations, down from 14 100 ha in 1987. Defoliation was severe for 3% of the area, moderate for 33%, and light for the remainder. Budworm populations in the Kamloops Region declined slightly to 875 ha following an increase in 1987. Near Holberg on northern Vancouver Island, mature western hemlock over 4830 ha were defoliated, up from 5 ha in 1987. In the eastern part of the Prince Rupert Region, where budworm populations in alpine fir stands have been common at fluctuating levels since 1982, new shoots over 58 670 ha were lightly to severely defoliated. Increased populations near Germansen Landing lightly infested white spruce.

On the Queen Charlotte Islands budworm populations declined significantly and lightly defoliated only 10 ha near Tow Hill on Graham Island. Defoliation of western hemlock stands on the Queen Charlotte Islands, mainly by the sawfly, is expected to decline further in 1989.

Collections of hemlock sawfly cocoons were made at 13 sites to evaluate sawfly survival and levels of parasitism. Sawfly survival was generally low but variable; adults emerged from an average of only 13% of the cocoons (range 0 to 40%) and the highest survival rate was at Harrison Island in Masset Inlet. Parasitism of cocoons by Ichneumonidae accounted for 34% of the mortality and the remainder was possibly caused by an entomopathogen. The highest parasitism (70%) occurred at Skidegate Narrows on Moresby Island. (L. Humble, Forestry Canada, Victoria, personal communication).

Increased blackheaded budworm populations defoliated western hemlock over an estimated 4830 ha on northern Vancouver Island. The infestation affected all age classes of western hemlock from William Lake east to Nahwitti Lake and south to Glerup Creek on the southern shore of Holberg Inlet. Small scattered infestations were also noted in Cape Scott Park. Limited aerial surveys were conducted in August 1988, but poor weather conditions prevented a more extensive survey which may have detected a greater area of defoliation. Defoliation is expected to increase in severity and area in 1989, based on the number of eggs per 10 m^2 of hemlock foliage at 10 sample sites near Holberg. The average egg count was 59 and ranged from 4 to 166. Based on relationships determined during past infestations, defoliation is forecast to be severe at three locations, moderate at five, and trace or light elsewhere. Consecutive years of severe defoliation could result in some tree mortality or top-kill. This will not be fully evident, however, until this infestation subsides. The last recorded infestation on Vancouver Island, from 1970 to 1973, defoliated western hemlock and amabilis fir over 164 000 ha from Jordan River to Holberg. Tree mortality did not occur and top-kill was limited to 10% of the trees in small areas on southern Vancouver Island.

Mature western hemlock in mixed hemlock-cedar stands in five pockets in the Kamloops Region were lightly to moderately defoliated over 875 ha, similar to 1987. Defoliation, for the second consecutive year, occurred in the Clearwater River drainage in Wells Gray Provincial Park; no defoliation was seen in the Upper Adams River drainage where defoliation occurred in 1987.

In the Prince Rupert Region, light defoliation of new shoots of white spruce and alpine fir in the Morice River, McKendrick Pass, and Hudson Bay Mountain areas was similar to that in 1987. Defoliation occurred for the first time along the Nilkitkwa and Chapman forest roads and near Francois Lake. Egg counts at four locations indicate continuing light to moderate defoliation of new foliage in 1989 in these areas. Populations in white spruce from Germansen Landing to Uslika Lake in the Prince George Region infested 10% of the shoots, up from endemic populations and trace defoliation in 1987.

Western hemlock looper

Lambdina fiscellaria lugubrosa

The infestations at Jervis Inlet in the Vancouver Region which severely defoliated western hemlock, cedar, maple and other deciduous understory trees and shrubs over about 90 ha in 1987 collapsed this year. The collapse is probably due to egg parasitism, as larvae were not present in the stand in 1988. About 75 western hemlock and 25 immature and mature western red cedar were killed as a result of the defoliation. Most of the western hemlock were predisposed by hemlock dwarf mistletoe, *Arceuthobium tsugense*, infection and cedar was predisposed by overstory shading.

Larch Pests

Larch casebearer
Coleophora laricella

Larch casebearer populations in western larch stands in southeastern British Columbia were at levels similar to those in 1987. Light defoliation in numerous pockets totalling several hundred hectares was widespread in the West Kootenay and pockets of moderate defoliation were common in the East Kootenay. Defoliation in the western part of the host range in the Kamloops Forest Region was minimal. At most of the 20 sites used for long-term parasite releases in the Nelson Region, defoliation was nil to generally light and moderate only near Castlegar. Parasitism at these sites ranged from 0 to 82% with a mean of 29% (median 23%), up 11% from 1987 (I. Otvos, Forestry Canada, Victoria, personal communication). Based on the numbers of overwintering larvae on fascicles of branch tips, defoliation of western larch is forecast to be light at 5 of the 20 sites, mostly in the Nelson Region, and negligible at the remainder. Increased populations are forecast at only two sites, declines are forecast at six, and no change is expected at the other sites.

Since the biological control program against larch casebearer was initiated in 1966, more than 15 000 specimens of *Chrysocharis laricinellae* or *Agathis pumila* have been released. No releases were made in 1988 and additional releases are not anticipated until the results to date can be further assessed.

Larch sawfly
Pristiphora erichsonii

Larch sawfly populations generally declined in western larch in the southeastern part of the Nelson Region, and in tamarack in the Yukon Territory and the northern part of the Prince Rupert Region. Populations increased, however, in the West Kootenay, and western larch and exotic larch near Haney in the Vancouver Region and at Terrace and Prince George were moderately defoliated.

For the first time since 1968 populations increased in western larch stands in the West Kootenay at Miller Creek near Grand Forks and western larch over 100 ha were moderately or severely defoliated. Following several years of fluctuations, populations in the East Kootenay declined and patches totalling 400 ha between Elko, Hosmer, and Fernie were lightly or moderately defoliated. Populations collapsed from undetermined causes in previously defoliated stands at Dutch Creek and where high numbers of larvae occurred north of Elko in 1987.

For the second consecutive year, tamarack in the Yukon Territory north of Watson Lake, from Frances Lake to Tuchitua and the Tungsten Road areas were light to moderately defoliated. Sawfly populations south of the Yukon border in the Prince Rupert Region declined and very lightly defoliated tamarack where moderate defoliation occurred in 1987.

Exotic larch in Terrace were defoliated mostly lightly to moderately for the second consecutive year, and larch in Prince George were lightly defoliated for the first time in more than 20 years. Defoliation averaged 60% on exotic larch at the University of British Columbia Research Forest near Haney in the Vancouver Region for the third consecutive year. This has resulted in top-kill of about 2 m on about 12% of the larch.

Duff samples under currently infested western larch at Hosmer, Elko and Wigwam creeks in the East Kootenay and at Miller Creek in the West Kootenay contained an average of 19, 30, 45, and 28 cocoons per 1000 cm^2. However, a high incidence of parasitism of the cocoons by a chalcid, *Dibrachys saltans*, should severely reduce the populations and result in little or no defoliation of western larch in the areas in 1989.

Larch budmoth
Zeiraphera improbana

Populations of larch budmoth increased very slightly at Johnstone Creek but caused no measurable damage. Populations elsewhere in the West Kootenay remained endemic, including sites of previous infestations at Hanna and Murphy creeks near Rossland and Aaron Hill near Castlegar.

Larch needle disease
Hypodermella laricis

Following two successive years of discoloration of western larch in the western and southeastern parts of the host range, new infections were greatly reduced.

Infection by *Hypodermella laricis* was severe over 650 ha along the Kootenay River and north of Canal Flats, and light in pockets in the Whiteswan Lake and lower White River areas and between Premier Lake and Finlay Creek. There was only very light scattered infection in the western part of the Nelson Region and in the eastern part of the Kamloops Forest Region where pockets of light infection over 5 to 10 ha occurred east of Vernon to Sugar Lake.

European larch canker

Lachnellula willkommii

Surveys for the potentially damaging European larch canker in western, alpine, eastern and some exotic larch stands in British Columbia were negative for the eighth successive year. A native larch canker continues to be found on immature western larch in the West Kootenay. The distribution of the European canker in North America remains limited to New Brunswick and Nova Scotia and several eastern states where small-diameter trees have been infected and killed.

Multiple Host Pests

Black army cutworm

Actebia fennica

Conifer seedlings and herbaceous ground cover were severely defoliated and some planting programs delayed by increased cutworm populations in 2-year-old burns in the Cariboo, Nelson, Prince George, and Prince Rupert regions. The worst damage was in one Engelmann spruce plantation in the Nelson Region; however, populations in other previously infested areas in the East Kootenay declined. Elsewhere in the province, defoliation was limited largely to herbaceous ground cover.

In the Cariboo Region, 60 to 100% of the Douglas-fir seedlings and most herbaceous ground cover in three 1986 burns near Bootjack Lake west of Likely were severely defoliated.

Black army cutworm larvae were present in the Kamloops Region but only in very low numbers in the Clearwater District. Very light feeding damage to herbaceous ground cover was recorded in one of eight sites burned in 1986, but spruce and pine seedlings were not damaged.

Conifer seedlings and herbaceous ground cover were defoliated in several recently planted sites in the Nelson Forest Region including the Giby fire but not in the Ram fire east of Canal Flats where high populations and severe defoliation occurred in 1987. Elsewhere in the East Kootenay, 88% of the seedlings near Bush Harbour were totally stripped; at the time of feeding there were 15 larvae per 1000 cm^2. Similar numbers (13/1000 cm^2) in CP 35 on Blackwater Ridge near Donald defoliated aspen and willow regeneration, but damage to conifer seedlings was minimal. High numbers of late-instar larvae were also observed at Hunter Creek east of Golden. Near Red Rock Harbor east of Mica Dam in the West Kootenay, 45% of the Engelmann spruce planted in 1987 in a 107-ha burn and a nearby 26-ha 1986 burn were stripped. This is the first cutworm infestation recorded in this area. All ground cover over half the area was totally consumed and pockets of complete defoliation were scattered throughout the remainder.

Increased populations in 1986 burns in the Prince George Region defoliated seedlings and ground cover. At East Twin Creek near McBride, white spruce and Douglas-fir seedlings and all the ground cover over 30 ha were severely defoliated. At Caine Creek north of Prince George, white spruce planted this year were not affected by increased numbers of cutworm but ground cover was lightly and moderately defoliated.

In the Prince Rupert Region, cutworms were more numerous than in 1987, particularly in the west; however, damage was restricted mostly to herbaceous ground cover. Of 31 sites surveyed in the eastern part of the region, seedlings were lightly damaged over about 1 ha at Corral Main and herbaceous ground cover, mainly fireweed, was defoliated at three others. Larvae (4 to 18 per 1000 cm^2) at three burns in the western part of the region in the Bell-Irving River drainage lightly defoliated abundant fireweed but seedlings were not damaged.

Variable levels of parasitism by Hymenoptera and Diptera were found in 11 mass-reared collections of black army cutworm larvae and pupae from the Nelson, Prince Rupert, and Prince George regions. In two new infestations near Golden, parasitism of cutworm larvae ranged from 11 to 19%. As well, the entomopathogen *Beauveria bassiana* killed 42% of the larvae reared from one location. In a single collection from the Giby fire in the Nelson Region, larval parasitism increased to 37% in 1988 from 2.3% in 1987. At six sites in the Prince Rupert Region, larval and pupal parasitism, respectively, averaged 33% (range 3 to 67%) and 22%. Larval parasitism at two sites in the Prince George Region averaged 44%. (L. Humble, Forestry Canada, Victoria, personal communication).

Populations are forecast to continue near most currently infested areas. This is based on 372 sticky traps baited with experimental pheromones which attracted up to 97 male moths per trap at 51 of 70 sites in four regions. Additionally, 23 of 80 traps at 9 of 16 sites in the Clearwater District in the Kamloops Forest Region attracted 37 male adults; the highest number per trap (5) at the Mud fire indicates low populations. Cutworms could pose a threat in 1989 plantings in the interior of British Columbia in areas that were slash-burned in 1987.

A contract to develop a predictive warning system linking moth catches in non-sticky pheromone traps with subsequent defoliation and seedling and vegetation damage completed its second field year and results are being analyzed. This study is building on earlier studies by Dr. R. Shepherd at Forestry Canada, Victoria in co-operation with FIDS.

Rhizina root disease

Rhizina undulata

Seedling mortality linked to infection by Rhizina root disease was found in 18 of 87 recently planted sites burned in 1987 in wetter parts of the Prince Rupert, Nelson, and Prince George forest regions. This was the first significant seedling mortality from this pathogen recorded by FIDS since 1969. Fruiting bodies were present in six additional areas but there was no evidence of seedling mortality.

In the Prince Rupert Region an average of 14% (range 3 to 34%) of the white spruce, Sitka spruce, and lodgepole pine seedlings were killed or dying in 10 plantations: four in the east from Houston to the Kispiox River Valley, and six in the west in the Nass and Bell-Irving river valleys. The greatest mortality was recorded north-east of Meziadin Lake where 17% of the lodgepole pine seedlings were killed and 17% were chlorotic and stunted adjacent to fruiting bodies.

In the Nelson Region an average of 9% (range 2 to 26%) of the Engelmann spruce, lodgepole pine, and Douglas-fir seedlings were killed in eight plantations, from Redding Creek west of Kimberley to Bush Arm and from Slocan to Revelstoke at Downie and Cariboo creeks. The highest (26%) occurred in a plantation in the Bush River Valley northeast of Golden.

The root disease was collected for the first time in the Prince George Region near Weedon Lake north of Prince George where 1% of the planted lodgepole pine seedlings were killed, but none were killed at Frank Lake where fruiting bodies were common.

Although no seedling mortality was reported in the Prince Rupert Region in 1987, fruiting bodies were abundant in burns and these provided inoculum for the mass fruitings and damage recorded this year. The moist and early 1988 summer weather provided ideal conditions for mycelial growth and subsequent attack of the roots of freshly planted seedlings.

Mass fruitings of *Rhizina* in forest situations may follow wild fires or prescribed burns. Since it is a poor competitor, the fungus normally survives for only a few years after the burn, after which it is succeeded by more aggressive fungi. Most seedling mortality occurs within the first year of infection but mortality of Douglas-fir on the same coastal sites was reported for two successive years in 1968/69. Mortality of lodgepole pine and western larch seedlings occurred in two plantations in the Prince Rupert Region in the same period.

In 1989, infection by *Rhizina* and seedling mortality is possible in 1988 burns in wetter sites.

Cone, seed, and seed orchard pests

Cone crops in British Columbia in 1988 were generally

good. Douglas-fir, grand fir, and cedar crops were heavy on eastern Vancouver Island but generally moderate in the interior. Interior spruce cone crops were heavy but seed yield was severely reduced due to infection by inland spruce cone rust, *Chrysomyxa pirolata*. Lodgepole and ponderosa pine crops in the interior were good.

Twelve coastal and five interior seed orchards were surveyed. Cooley spruce gall adelgid, *Adelges cooleyi*, infested Douglas-fir again at six coastal orchards, Sitka spruce at two orchards, and white spruce at one interior seed orchard. Balsam woolly adelgid, *Adelges piceae*, lightly to moderately infested twigs on amabilis fir at two orchards near Victoria which are within the infestation regulation zone. Eighteen percent of the immature yellow cedar cones in a coastal seed orchard were infested by a gall midge, *Contarinia* sp., for the second consecutive year. Pine needle sheathminer, *Zelleria haimbachi*, was common in low numbers in new shoots of lodgepole pine at four interior orchards.

Spruce cone crops were affected by several important pests, including inland spruce cone rust which infected cones at 20 locations in the Prince Rupert Region. Spruce cone rust was also present to a lesser degree in the Nelson and Prince George forest regions. Infection was most severe in the northern part of the Prince Rupert Region where 50 to 100% of the cones were infected over a widespread area. Infection in the interior part of the Prince Rupert Region averaged 16% at six sites, 8% at five sites in the Nelson Region and 7% at two sites in the Prince George Region. The spruce cone maggot, *Strobilomyia neanthracinum* [=*Lasiomma anthracina*], destroyed over half of the seeds in 32% of the white, Engelmann and Sitka spruce cones at 52 sites in five forest regions. The proportion of cones that were affected ranged from 10% in the West Kootenay to 55% in the Prince George Region. Spruce seed moth, *Cydia strobilella*, infested an average of 21% of the spruce cones at 14 sites in four forest regions; the level of infestation ranged from 15% in the eastern part of the Cariboo Region to 45% in the Prince George Region. Douglas-fir cone crops in the interior and parts of the lower mainland were infested by two major seed pests and a coneworm. Douglas-fir seed chalcid, *Megastigmus spermotrophus*, infested and destroyed seed in an average of 20% (range 12 to 24%) of the Douglas-fir cones at 10 locations in the Kamloops Region and in the East Kootenay. An average of 8% of the cones were mined and destroyed by fir coneworm, *Dioryctria abietivorella*, which inflicted the most damage at Indian Gardens west of Kamloops. Seeds in 5 to 20% of the Douglas-fir cones at 15 locations in the southern half of British Columbia were destroyed by Douglas-fir cone moth, *Barbara colfaxiana*; damage was most severe in the East Kootenay and in the Okanagan Valley. A pine cone borer, *Eucosma recissoriana*, infested up to 30% of the lodgepole pine cones in two of four stands sampled in the western part of the Prince Rupert Region.

Pests of young stands

Surveys of young, 2- to 25-year-old, natural and planted conifer stands across the province continued to identify major pests and their impact. More than 11 770 trees in 914 plots in 129 stands were examined in 1988. Pest problems included pine and spruce terminal weevils, pine root collar weevil, western gall rust, animal damage mostly to pine by voles, hares and squirrels, pine stem rusts, and adelgids on Douglas-fir and spruce. The overall incidence of damage by the pests was variable and often severe in localized areas. Tree mortality was usually less than 10%.

Across British Columbia new attacks by pine terminal weevil, *Pissodes terminalis*, averaged less than 5% in 16 of 59 lodgepole pine stands. Infections by western gall rust, *Endocronartium harknessii*, occurred mostly on branches and were highest (24% of the trees) in four stands in the Okanagan and less than 10% in 15 infected stands in five regions.

Leader mortality by attacks of spruce weevil, *Pissodes strobi*, varied. On Vancouver Island 50% of the terminals in one of seven plantations were killed; 5 to 10% of the terminals were killed at the other six plantations. Current attack near Bella Coola averaged 28% on 2- to 10-m Sitka spruce. Additionally, more than 50% of the terminals were killed in five areas over more than 3000 ha on the west coast of Vancouver Island surveyed by the British Columbia Forest Service. In the western part of the Prince Rupert Region, weevil attacks averaged 24% (range 5 to 44%) in 10- to 15-year-old Sitka spruce at 22 sites. New attacks on Engelmann spruce at six sites in the Nelson Region averaged 11% (range 3 to 35%).

Increased populations of pine root collar weevil, *Hylobius warreni*, infested immature lodgepole pine in 15 of 59 planted and naturally regenerated sites in six forest regions and killed up to 15% of the trees. Near Hazelton in the Prince Rupert Region an average of 76% of the 4- to 20-year-old lodgepole pine in five stands were infested but to date only about 5% have been killed.

Stem infections on suppressed naturally regenerated lodgepole pine by Comandra blister rust, *Cronartium*

comandrae, were prevalent in the eastern part of the Prince Rupert Region in the Morice and Lakes TSAs but less common in the Bulkley and Kispiox TSAs. Rodent feeding around the edges of the infections was common. In the Cariboo Region, stem cankers of stalactiform blister rust, *C. coleosporioides*, were up to 3 m long on about half of the intermediate lodgepole pine over 10 ha south of Hanceville. About 2% of the pine were killed by infection and rodent girdling of the cankers, which also were common on living trees, and by attacks by pine engraver beetle, *Ips pini*.

Cooley spruce gall adelgid, *Adelges cooleyi*, frequently infested and discolored more than 50% of the new tips of interior white and Engelmann spruce and Douglas-fir; however, immediate and long-term impact of the damage is considered minimal.

Less common pests in young stands included Armillaria root disease, *Armillaria* sp., which infected small numbers of trees in parts of the Nelson and Kamloops regions. The conifer-aspen rust, *Melampsora medusae*, was common in young stands in the Prince George Region; larch needle disease, *Meria laricis*, was also common in the Nelson Region.

Animal damage

Feeding damage to recently planted conifer seedlings by high numbers of voles, *Microtus* sp., increased significantly in the western part of the Prince Rupert Region and killed seedlings on southern Vancouver Island. Damage was not evident, however, in the eastern part of the Prince Rupert Region where seedling mortality was prevalent in 1987.

Feeding damage occurred on an average of 10 (range 2 to 56%) of the lodgepole pine and Sitka spruce seedlings planted at 13 sites in 1986-88 from the Kitimat Valley to the Bell-Irving River Valley, but seedling mortality was less than 5%. Voles in a Forestry Canada research site west of Mesachie Lake on southern Vancouver Island killed about 50 western hemlock and western red cedar seedlings near old stumps over about 1 ha. Terminal clipping of 1- to 2-year-old lodgepole pine on laterals of 10- to 15-year-old Sitka spruce, caused by hares, *Lepus* sp., occurred sporadically in the western part of the Prince Rupert Region on 8 and 25% of the pine seedlings at two of four sites on the Kalum Road and 6% of the cedar and 21% of the Sitka spruce in a plantation at Lakelse. Although minor clipping of lower branches at three plantations affected 92% of the spruce at one plantation in the Kitimat River Valley, 67% at Nalbeelah Creek, and 20% at Kalum Lake, the damage was very light and patchy and little mortality is expected.

Half the recently spaced immature lodgepole pine in pockets of 1 to 2 ha throughout a 50-ha site on the Palmer Lake Road in the Cariboo Region were completely girdled at the base by rodents, seriously affecting stocking. Numerous whitebark pine in the Heckman Pass area west of Anahim Lake were killed by girdling about 1 m above ground level. Rodent feeding was common also on lodgepole pine infested by blister rust south of Hanceville.

Mortality of young and semimature conifers in the western part of the Prince Rupert Region, killed by porcupine chewing of patches of bark on stems and branches, continues to be common.

Climatic injury

The increased number of scattered dead and dying conifers across British Columbia, particularly in drier parts of the south coast in the Vancouver Region, was attributed mostly to the cumulative drought conditions during 1985-1987. In the Victoria area, precipitation during the April-September growing seasons for 1985-87 averaged 25% less than the 30-year norm, and the temperatures were at or slightly above the norm. Mortality of mainly immature western red cedar and grand fir and some western hemlock was most common and patchy on the Saanich Peninsula, the Gulf Islands, and the Sunshine Coast, particularly on rocky sites and stand fringes. Secondary bark beetle attacks by *Scolytus ventralis* were common in the affected grand fir and attacks by *Phloeosinus sequoiae* were common in affected western red cedar.

Conifer mortality in interior regions was common but not exclusively associated with roadsides where winter salting may have been a contributing factor. Recently dead lodgepole pine and Douglas-fir were numerous in the Cariboo Region, particularly along Highway 97 between Clinton and Williams Lake. Higher than normal numbers of recently dead Douglas-fir and ponderosa pine occurred in groups of 5 to 10 along roadsides in the Kamloops Region in the Kamloops, Lillooet, and Okanagan TSAs. In the West Kootenay, 20 to 40% of the young lodgepole pine in pockets of 5 to 20 ha at McKinney and Trapping creeks were dead or severely affected by drought. Between McBride and Valemount in the Prince George Region about 40% of the roadside lodgepole pine saplings were lightly discolored; this

Acid rain monitoring

Observations for acid rain symptoms, or symptoms which mimic those of acid rain, were made at 15 permanent sample plots established across British Columbia since 1984. It is recognized that many factors, including a wide range of insects and diseases as well as climatic factors such as drought and regional air pollution, contribute to decline. While Forestry Canada continues to monitor forest health and continues to be concerned about potential acid rain and long-range transportation of air pollutants, no direct link or scientific proof of any damage caused by acid rain in western forests has yet been established.

More than 10 tree species and many species of ground cover were examined one or more times during 1988 in the 15 Acid Rain National Early Warning System (ARNEWS) plots. Premature discoloration and loss of older needles of Douglas-fir and western hemlock at four sites were largely attributed to poor site conditions and drought conditions in 1985-87. A tip blight, *Sirococcus strobilinus*, in plots at the University of British Columbia Research Forest near Haney and in the Capilano Watershed moderately to severely infected 10 to 15% of the new hemlock shoots. Various needle or leaf fungi and defoliators were present at low levels, including *Septoria alni*, which caused moderate foliage discoloration of alder on 20% of the trees in one plot.

Light mottling on birch leaves in the Coquitlam plot are symptomatic of ozone damage and some of the light chlorosis of older foliage on western hemlock are visually similar to air pollution effects such as the damage caused by sulphur dioxide. The plots will continue to be monitored closely, and chemical analysis of foliage will be completed and interpreted. Pollution experts will be shown the material and the plots if the damage continues in 1989. Mixed-age spruce in a plot west of Castlegar were lightly mottled, and the causal agent was identified as abiotic. There was no evidence of change in the condition of trees and ground cover in plots near Terrace, Prince George, Penticton, and Campbell River.

Fume damage

New and older needles of about 60% of the mixed-age class western hemlock were discolored in patches within about 6 km of the pulp mill at Port Alice on northern Vancouver Island; this was likely caused by sulphur dioxide. Over the long term this damage has resulted in dead tops on the hemlock in widely scattered patches over about 300 ha on the east side of Neroutsos Inlet.

Foliage from hemlock in long-term study plots established by the British Columbia Ministries of Environment and of Forests is being studied by Forestry Canada to determine if a chemical indicator of stress exists.

Deciduous and Ornamental Tree Pests

Tent caterpillars
Malacosoma spp.

Severe defoliation of trees and shrubs by forest tent caterpillar, *Malacosoma disstria*, was more widespread in 1988 in parts of the Cariboo and Prince George regions and in the East Kootenay (Map 4). Populations in the West Kootenay and in the Kamloops Region declined. Populations of western tent caterpillar, *Malacosoma californicum pluviale*, declined in southwestern British Columbia but were common in the Kamloops and Nelson regions and near Bella Coola for the second consecutive year.

Northwest of Prince George, populations increased for the third consecutive year and defoliated trembling aspen in 120 infestations over 43 300 ha, a fivefold increase from 1987. In the Peace River area, defoliation of trembling aspen and cottonwood declined for a second year to 5000 ha in 15 separate areas, down from 8650 ha in 1987. For the first time in 4 years populations in the Cariboo Region increased and severely defoliated trembling aspen over 460 ha in 28 pockets, mostly between Green Lake and Lac des Roches east of 100 Mile House. In the Nelson Region, population increases resulted in widespread moderate and severe defoliation of trembling aspen over 1500 ha in 24 pockets from Creston to Fernie and north to Donald. Additional pockets of light defoliation varying in size from 0.5 to 5 ha were numerous from Wardner to Golden. Populations in the West Kootenay collapsed following four consecutive years of infestation.

Defoliation of trembling aspen, cottonwood and other deciduous trees and shrubs is forecast to continue in most recently infested stands near Prince George and Pouce Coupe and from Creston to Donald in the East Kootenay. This prediction is based on overwintering egg samples from 10 areas.

The decline of western tent caterpillar populations in southwestern British Columbia continued in 1988 following infection and mortality of larvae by a nuclear polyhedrosis virus in 1987. Populations in the Okanagan Valley lightly defoliated trembling aspen and roadside shrubs in widely scattered pockets of 0.5 to 4 ha; similar damage was recorded in 1987. For the second consecutive year, alder, birch, and other deciduous trees and shrubs in the Bella Coola Valley in the Vancouver Region were lightly to severely defoliated, most severely near Hagensborg. High numbers of colonies were common on deciduous trees and shrubs in the West Kootenay and for the first time since 1978 in the East Kootenay.

Gypsy moth
Lymantria dispar

About 8000 sticky traps were monitored throughout British Columbia in the thirteenth year of a cooperative program with Agriculture Canada (Plant Health), British Columbia Ministry of Forests, and FIDS. Only 12 adult male gypsy moths were trapped this year in British Columbia in 12 pheromone-baited sticky traps in seven areas. This compares with 216 moths in 56 traps in eight areas in 1987. Male moths were caught near Kelowna (4) and Canadian Forces Base Colwood (1) for the third consecutive year. Male moths were caught near Parksville (2) for the second consecutive year. New catches were made at Point Roberts (2), Coquitlam (1), West Vancouver (1), and at Yard Creek Provincial Park near Sicamous (1). No new egg masses have yet been found. The capture near Sicamous was in one of 291 traps set out by FIDS in 251 forested recreation areas in national and provincial parks, in commercial campgrounds, or near military bases.

Bacillus thuringiensis was applied by Agriculture Canada between April 27 to June 14, 1988 at a concentration of 30 BIU/ha in parts of Kelowna, Colwood and Parksville. In Kelowna and Colwood aerial applications complemented by ground applications were used over 112 and 40 ha, respectively. Ground based sprays were used over 4.5 ha at Parksville. The trapping results discussed previously indicated successful control.

Satin moth
Leucoma salicis

Increased satin moth populations severely defoliated poplar over about 150 ha southeast of Chilliwack and near Harrison Hot Springs in the Vancouver Region. Mortality of late instar larvae in the Chilliwack infestation was high due to infection by an unidentified virus or disease. Localized infestations lasting 1 or 2 years have

occurred periodically in the Fraser Valley since the 1920's, most recently in 1975.

There was no evidence of satin moth in the Kamloops Region where small areas of black cottonwood and trembling aspen were severely defoliated during the previous 3 years.

Western winter moth

Erannis tiliaria vancouverensis

Western winter moth populations increased in a second year of infestation in the Vancouver and Kamloops forest regions, but populations collapsed in the Cariboo Region.

Vine and broadleaf maple over an estimated 110 ha throughout Sasquatch Park north of Harrison Hot Springs were severely defoliated. Light to moderate defoliation of alder, willow, and maples was widespread in the Skagit River Valley, Alexandria Park, Gilt Creek, Anderson River, and North Bend areas in the Fraser Canyon. High numbers of adults in flight near Hope in November indicate continuing populations in the Upper Fraser Valley and canyon areas in 1989.

In the Kamloops Region, defoliation of maple and birch varied from light to severe in numerous scattered patches of 0.5 to 5 ha in the Shuswap Lake area, including, for the second consecutive year, the Turtle and Clearwater river valleys and the North Thompson River Valley from Little Fort to Vavenby.

There was no evidence of populations or defoliation in parts of the Cariboo Region where patches of mixed hardwoods were defoliated in 1986 and 1987.

Infestations occur periodically in coastal and interior deciduous forests and usually last 2 or 3 years. This would indicate declining populations in 1989 where high populations have persisted for three consecutive years.

Winter moth

Operophtera brumata

Defoliation of deciduous trees, mainly Garry oak, shrubs, and fruit trees, was very light throughout southeastern Vancouver Island. Populations remained very low for the fourth consecutive year over this area where defoliation had often been severe since the first report of winter moth in 1970. More than 300 000 parasites were released from 1979 to 1981.

Combined parasitism by *Cyzenis albicans* and *Agrypon flaveolatum* in 1988 was about 70% at seven sites selected for monitoring (I. Otvos, Forestry Canada, Victoria, personal communication).

Large aspen tortrix

Choristoneura conflictana

For the first time since 1984, increased tortrix populations in the Yukon Territory defoliated trembling aspen from west of the Klondike Highway junction along the Alaska Highway to the Takhini River bridge. Defoliation was severe over 800 ha and light over 200 ha and is expected to continue in the area next year. Aspen stands in the Cassiar TSA in northwestern British Columbia were severely defoliated over 3200 ha in 18 infestations.

Poplar shoot blight

Venturia macularis

Severe infection and discoloration of trembling aspen by shoot blight was widespread in parts of the Prince George Region, but significantly less severe and widespread in parts of the Cariboo and Nelson regions than in 1987. Lightly infected aspen groves were widespread in the western part of the Prince Rupert Region.

Discoloration was most severe over several thousand hectares along the east side of Williston Lake north of Mackenzie and was common near the Hart Highway and Manson Creek and along the Liard Highway. In the Cariboo Region discoloration of groups of trembling aspen was very light and scattered, mostly in the northeast; discoloration occurred to a lesser extent in the Big Bar Mountain area west of Clinton. No discoloration was evident in the western part of the region where moderately infected trees were common and widespread in 1987. Infection of aspen groves in the East Kootenay declined to endemic levels. In the western part of the Prince Rupert Region infection was light and widespread, similar to that in 1987.

Birch leaf miner

Lyonetia sp.

Discoloration of patches of white birch by the skeletonizer in some areas of the northern part of the East Kootenay in the Nelson Forest Region occurred for the fourteenth consecutive year, and increased in the eastern part of the West Kootenay. Discoloration was severe between Golden and Revelstoke and moderate in drainages in the Purcell Mountains west of the Rocky

Mountain Trench. In the Kaslo and Duncan Lake areas, defoliation increased to light and moderate.

Dogwood leaf blotch (Anthracnose)

Gloeosporium sp.

Infection of dogwood trees throughout their range in southwestern British Columbia was more severe and widespread in 1988. This was attributed to a wetter than normal spring. In the lower mainland severe infection of most trees at Mt. Seymour Provincial Park resulted in premature loss of foliage, particularly in the lower crowns. On the Sunshine Coast, loss of up to 90% of foliage and dieback of up to 60% of the branches were common. Less severe infections were common throughout the Fraser Valley and in the Fraser Canyon north to Alexandria.

New Records of Occurrence and Distribution

During 1988, about 80 collections were new regional records. Collections of European mistletoe, *Viscum album*, at four sites in Victoria were a first Canadian record and only the second for North America. Nineteen disease and 10 insect collections were new records within either British Columbia or the Yukon Territory. Five insect collections represented significant extensions of known distributions within the region and 46 diseases were recorded for the first time in this region on new hosts. Most of the disease records were saprophytes or relatively minor foliage or bark disorders or fungi such as *Rhizina undulata* on lodgepole pine and Engelmann spruce; although these species were known to be susceptible, this disease had not previously been collected on them in British Columbia.